Illicit stimulant use in the population monitored by wastewater analyses

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This thesis is dedicated to my Mom and Dad

谨以此论文献给我的父母

DECLARATION

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PUBLICATIONS INCLUDED IN THIS THESIS

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Chen C.*, Kostakis C., Harpas P., Felgate P. D., Irvine R. J., White J. M. (2011). Marked decline in 3,4-methylenedioxymethamphetamine (MDMA) based on wastewater analysis. Journal of Studies on Alcohol and Drugs, 72(5): 737–740.

Chen C.*, Kostakis C., Irvine R. J., White M. J. (2013). Increases in use of novel synthetic stimulant are not directly linked to decreased use of 3,4-methylenedioxy-N-methylamphetamine (MDMA). Forensic Science International, 231(1–3): 278–283.

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…… Chang Chen, 16/8/2013

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ABSTRACT

Illicit stimulant use is a global problem, and accurate and timely information on population stimulant use is essential. However, traditional monitoring methods based on surveys and reporting systems have some limitations, which include the accuracy of the data collected, its relevance to the population as a whole, and the long delays in reporting in a rapidly changing drug scene. These limitations are problematic when using the collected data to develop health and policing policies. Analysis of community wastewater has been suggested to be an objective and quick method to provide supplementary data. However, a detailed knowledge of the pharmacology and chemistry of drugs is required combined with development and validation of techniques before this method is universally applied.

The general aims of this thesis were to develop and validate the method of wastewater analysis, and then apply it to monitor illicit stimulant use in the general population. The analytical method used in this study was mainly solid-phase extraction coupled with liquid chromatography- tandem mass spectrometry.

Firstly, pre-analysis loss of drugs and metabolites were evaluated. The results from this study showed that negligible loss of the studied drugs occurred after filtration, and all analytes except cocaine and 6-monoacetylmorphine are relatively stable in wastewater. For cocaine use monitoring, its metabolite benzoylecgonine is a more suitable analytical target for stability reasons. To stabilise 6-monoacetylmorphine, the addition of sodium metabisulphite is recommended.

Secondly, wastewater analysis was applied to monitor the use of illicit stimulants cocaine, methamphetamine and 3,4-methylenedioxy-N-methylamphetamine (MDMA) in the State of South Australia, Australia. Data were collected for international comparisons, geographical comparisons and weekly use pattern assessments.

Continued monitoring of the wastewater revealed a decline in MDMA use in Adelaide, which provided objective data to support the globally reported MDMA shortage starting from 2009.

Since late 2000s, there has been an increase in the use of novel synthetic stimulants. It was suggested that this increase might be associated with the MDMA decline, but it was also possible that these two phenomena were not related. To verify these hypotheses, an analytical method for the analysis of some of the most reported synthetic stimulants was developed, validated and applied. Results showed some sporadic increases in the use of new synthetic stimulants during 2010 and 2011, but these increases were not directly linked with the MDMA decline, suggesting the novel synthetic stimulants have not replaced MDMA.

In conclusion, this thesis developed and validated the method of wastewater analysis and gained important information on stimulant use in the population, which cannot be obtained via other monitoring approaches.

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STATEMENT OF AUTHORSHIP AND CONTRIBUTION

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Mr Chen (candidate) designed and performed the experiments, interpreted the data, wrote the manuscript and submitted it for publication.

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Mr Kostakis was involved in the experimental design and supervision, and evaluated the manuscript.

Signed …… *Date*……

Associate Professor Irvine was involved in the data interpretation and manuscript preparation.

Signed …… *Date*……

Mr Felgate was involved in the sample analysis and manuscript evaluation.

Signed …… *Date*……

Professor White was involved in the data interpretation and contributed to the manuscript preparation.

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Irvine R. J., Kostakis C., Felgate P. D., Jaehne E. J., **Chen C.**, White J. M. (2011). Population drug use in Australia: a wastewater analysis. Forensic Science International, 210(1–3): 69–73.

Mr Chen (candidate) was involved in the sample and data analysis, graphical presentation of the data and manuscript preparation, and submitted the manuscript for final publication.

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Associate Professor Irvine was involved in the experimental design and sample collection, and had a major input in the manuscript preparation.

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Mr Kostakis developed the analytical method and had a major contribution to the sample analysis. He was also involved in the data interpretation and manuscript preparation.

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Mr Felgate was involved in the sample analysis and manuscript preparation.

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Dr Jaehne conducted the majority of the statistical analysis and graphical presentations of the collected data.

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Professor White was involved in the experimental design, sample collection and manuscript preparation.

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Mr Chen (candidate) had a major contribution to the sample and data analysis, as well as manuscript preparation and submission.

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Mr Kostakis was involved in the sample collection and analysis, and contributed to the manuscript preparation.

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Mr Harpas provided roadside drug testing data in this manuscript.

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Mr Felgate was involved in the sample analysis and manuscript preparation.

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Associate Professor Irvine was involved in the manuscript evaluation.

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Professor White designed the study and critically evaluated the manuscript.

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Professor White critically evaluated the manuscript.

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ABBREVIATIONS

5-HT: 5-hydroxytryptamine (serotonin)

AIDS: acquired immunodeficiency syndrome

AMP: amphetamine

ATS: amphetamine-type stimulant

BE: benzoylecgonine

BZP: benzylpiperazine

CNS: central nervous system

COC: cocaine

COD: codeine

COT: cotinine

CRS: cocaine-related substance

DA: dopamine

EDRS: Ecstasy and Related Drugs Reporting System

EMCDDA: European Monitoring Centre for Drugs and Drug Addiction

GC: gas chromatography

GDP: gross domestic product

HHA: 3,4-dihydroxyamphetamine

HHMA: 3,4-dihydroxymethamphetamine

HILIC: hydrophilic interaction liquid chromatography

HPLC: high performance liquid chromatography

IDRS: Illicit Drug Reporting System

LC: liquid chromatography

LLE: liquid-liquid extraction

ITMS: ion trap mass spectrometer

LVI: large-volume injection

MA: methamphetamine

MAM: 6-monoacetylmorphine

MDA: 3,4-methylenedioxyamphetamine

MDMA: 3,4-methylenedioxy-N-methylamphetamine

MDPV: methylenedioxypyrovalerone

MOR: morphine

MS: mass spectrometry

MTD: methadone

$Na_2S_2O_5$: sodium metabisulphite

NDARC: National Drug and Alcohol Research Centre

NE: norepinephrine

NIDIP: National Illicit Drug Indicators Project

POCIS: polar organic chemical integrative sample/sampler

RSD: relative standard deviation

SPE: solid-phase extraction

TFMPP: 3-trifluoromethylphenylpiperazine

TQMS: triple quadruple mass spectrometer

UNODC: United Nations Office on Drugs and Crime

UPLC: ultra performance liquid chromatography

WHO: World Health Organisation

WWTP: wastewater treatment plant